U.S. DEPARTMENT OF ENERGY
DEPARTMENT-WIDE
FUNCTIONAL AREA QUALIFICATION STANDARD

INSTRUMENTATION AND CONTROL FUNCTIONAL AREA QUALIFICATION STANDARD

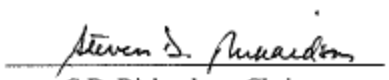
DOE Defense Nuclear Facilities Technical Personnel

U.S. Department of Energy
Washington, D.C. 20585

December 1999

APPROVAL

The Federal Technical Capability Panel consists of senior Department of Energy managers responsible for overseeing the Federal Technical Capability Program. This Panel is responsible for reviewing and approving the Qualification Standard for Department-wide application. Approval of this Qualification Standard by the Federal Technical Capability Panel is indicated by signature below.



S.D. Richardson, Chair
Federal Technical Capability Panel

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ACKNOWLEDGMENT

The Savannah River Operations Office is the Sponsor for the Instrumentation and Control Functional Area Qualification Standard. The Sponsor is responsible for coordinating the development and/or review of the Functional Area Qualification Standard by subject matter experts to ensure that the technical content of the standard is accurate and adequate for Department-wide application for those involved in Instrumentation and Control. The Sponsor, in coordination with the Federal Technical Capability Panel, is also responsible for ensuring that the Functional Area Qualification Standard is maintained current.

The following subject matter experts (SMEs) participated in the original development and review of the revised qualification standard:

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FUNCTIONAL AREA QUALIFICATION STANDARD

FUNCTIONAL AREA

Instrumentation and Control

PURPOSE

The Department's Federal Technical Capability Program Policy, issued by the Secretary in December 1998, commits the Department to continuously strive for technical excellence. The Technical Qualification Program, along with the supporting technical Functional Area Qualification Standards, complements the personnel processes that support the Department's drive for technical excellence. In support of this goal, the competency requirements defined in the technical Functional Area Qualification Standards should be aligned with and integrated into the recruitment and staffing processes for technical positions. The technical Functional Area Qualification Standards should form, in part, the primary basis for developing vacancy announcements, qualification requirements, crediting plans, interviewing questions, and other criteria associated with the recruitment, selection, and internal placement of technical personnel. Office of Personnel Management minimum qualification standards will be greatly enhanced by application of appropriate materials from the technical Functional Area Qualification Standards.

The technical Functional Area Qualification Standards are not intended to replace the U.S. Office of Personnel Management's (OPM) Qualifications Standards nor other Departmental personnel standards, rules, plans, or processes. The primary purpose of the Technical Qualification Program is to ensure that employees have the requisite technical competency to support the mission of the Department. The Technical Qualification Program forms the basis for the development and assignment of DOE personnel responsible for ensuring the safe operation of defense nuclear facilities.

APPLICABILITY

The Instrumentation and Control Functional Area Qualification Standard establishes common functional area competency requirements for Department of Energy Instrumentation and Control personnel who provide assistance, direction, guidance, oversight, or evaluation of contractor technical activities impacting the safe operation of defense nuclear facilities. The technical Functional Area Qualification Standard has been developed as a tool to assist DOE Program and Field offices in the development and implementation of the Technical Qualification Program in their organization. Program and Field offices may choose to use this technical Functional Area Qualification Standard as-is, or they may use parts of it to facilitate the development of their own unique Technical Qualification Standards. In either case, satisfactory and documented attainment of the competency requirements contained in this technical Functional Area Qualification Standard, or similar Standards, ensures that Instrumentation and Control personnel possess the requisite competence to fulfill their functional area duties and responsibilities. Office/Facility-Specific Qualification Standards supplement this technical

Functional Area Qualification Standard and establish unique operational competency requirements at the Headquarters or Field element, site, or facility level.

IMPLEMENTATION

This technical Functional Area Qualification Standard identifies the technical competency requirements for Instrumentation and Control personnel. Although there are other competency requirements associated with the positions held by Instrumentation and Control personnel, this Functional Area Qualification Standard is limited to identifying the specific technical competencies. The competency statements define the expected knowledge and/or skill that an individual must meet. Each of the competency statements is further explained by a listing of supporting knowledge and/or skill statements. **The supporting knowledge and/or skill statements are not requirements and do not necessarily have to be fulfilled to meet the intent of the competency.**

The competencies identify a familiarity level, a working level, or an expert level of knowledge; or they require the individual to demonstrate the ability to perform a task or activity. These levels are defined as follows:

> **Familiarity level** is defined as basic knowledge of or exposure to the subject or process adequate to discuss the subject or process with individuals of greater knowledge.
>
> **Working level** is defined as the knowledge required to monitor and assess operations/activities, to apply standards of acceptable performance, and to reference appropriate materials and/or expert advice as required to ensure the safety of Departmental activities.
>
> **Expert level** is defined as a comprehensive, intensive knowledge of the subject or process sufficient to provide advice in the absence of procedural guidance.
>
> **Demonstrate the ability** is defined as the actual performance of a task or activity in accordance with policy, procedures, guidelines, and/or accepted industry or Department practices.

Headquarters and Field elements shall establish a program and process to ensure that Instrumentation and Control personnel possess the competencies required of their position. That includes the competencies identified in this technical Functional Area Qualification Standard or a similar Standard developed by the organization. Documentation of the completion of the requirements of the Standard shall be included in the employee's training and qualification record.

Equivalencies may be granted for individual competencies based upon an objective evaluation of the employee's prior education, experience, and/or training. Equivalencies shall be granted in accordance with the policies and procedures of the program or field office. The supporting knowledge and/or skill statements, while not requirements, should be considered before granting equivalency for a competency.

Training shall be provided to employees in the Technical Qualification Program to those do not meet the competencies contained in the technical Functional Area Qualification Standard. Departmental training will be based upon appropriate supporting knowledge and/or skill statements similar to the ones listed for each of the competency statements. Headquarters and Field elements should use the supporting knowledge and/or skill statements as a basis for evaluating the content of any training courses used to provide individuals with the requisite knowledge and/or skill required to meet the technical Functional Area Qualification Standard competency statements.

EVALUATION REQUIREMENTS

Attainment of the competencies listed in this technical Functional Area Qualification Standard should be documented by a qualifying official or the immediate supervisor of Instrumentation and Control personnel using any of the following methods:

- Documented evaluation of equivalencies
- Written examination
- Documented oral evaluation
- Documented observation of performance

CONTINUING EDUCATION, TRAINING AND PROFICIENCY

Instrumentation and Control personnel shall participate in continuing education and training as necessary to improve their performance and proficiency and ensure that they stay up-to-date on changing technology and new requirements. This may include courses and/or training provided by:

- Department of Energy
- Other government agencies
- Outside vendors
- Educational institutions

A description of suggested learning proficiency activities, and the requirements for the continuing education and training program for Instrumentation and Control personnel are included in Appendix A of this document.

DUTIES AND RESPONSIBILITIES

The following are the typical duties and responsibilities expected of DOE defense nuclear facility technical personnel assigned to the Instrumentation and Control Functional Area:

A. Review the management and technical oversight of the design, construction, and modification process.

B. Serve as a subject matter expert and technical resource for instrumentation and control systems.

C. Inspect and evaluate instrumentation and control systems for sage and efficient operation, maintenance, and testing.

D. Participate in accident investigation and problem-solving activities.

E. Review and participate (as appropriate) in the development, review, and coordination of Department of Energy Orders, standards, and guidance documents.

F. Evaluate Contractor compliance with relevant Department of Energy Orders, standards, and codes.

G. Review and assess authorization basis documentation.

H. Evaluate instrumentation and control system conformity to authorization basis documentation and other design basis documents.

I. Audit facility instrumentation and control systems and components for consistency between physical configuration, plant documentation, and design requirements.

J. Participate in department and industry best-practices working groups.

Position-specific duties and responsibilities for Instrumentation and Control personnel are contained in their Office/Facility-Specific Qualification Standard or Position Description.

BACKGROUND AND EXPERIENCE

The U. S. Office of Personnel Management's Qualification Standards Handbook establishes minimum education, training, experience, or other relevant requirements applicable to a particular occupational series/grade level, as well as alternatives to meeting specified requirements.

The preferred education and experience for instrumentation and control personnel is:

1. Education:

   Bachelor of Science degree in Electrical Engineering or a technical or scientific field; or meet the alternative requirements specified in the Qualification Standards Handbook.

2. Experience:

   Industry, military, Federal, state or other directly related background that has provided specialized experience in instrumentation and control system engineering. Specialized experience may be demonstrated through possession of the competencies outlined in the Standard.

REQUIRED TECHNICAL COMPETENCIES

Each of the competency statements defines the level of expected knowledge and/or skill that an individual must possess to meet the intent of this Technical Qualification Standard. **The supporting knowledge and/or skill statements further describe the intent of the competency statements but are not requirements.**

Note: When regulations or Department of Energy directives or other industry standards are referenced in the Qualification Standard, the most recent revision should be used.

1. Instrumentation and control personnel shall demonstrate a working level knowledge of fundamental electrical theory.

Supporting Knowledge and/or Skills

a. Define and discuss the following terms:

- Voltage
- Current
- Power
- Conductor
- Insulator
- Inductance
- Capacitance
- Impedance
- Electromagnetic force
- Electromagnetic field
- Frequency

b. Discuss Ohm's Law.

c. Discuss Kirchoff's Law.

d. Discuss the relationships in electrical circuits between voltage, current, resistance, impedance, and power.

e. Discuss the function of the following components in an electrical circuit:

- Resistor
- Capacitor
- Inductor
- Diode
- Rectifier
- Transformer
- Relay
- Contact
- Fuse
- Time delay relay

- Overcurrent relay
- Undervoltage relay
- Switches
- Silicon controlled rectifiers

2. Instrumentation and control personnel shall demonstrate a working level knowledge of the following basic electrical equipment:

- **Batteries**
- **Motors and generators**
- **Transformers**
- **Backup power supplies**
- **Electrical switchgear and transmission equipment**

Supporting Knowledge and/or Skills

a. Discuss the basic principle by which the following components produce current:

- Battery
- Direct Current generator
- Alternating Current generator
- Thermocouple

b. Discuss the various types of batteries used in electronic components. Include in the discussion the following elements of battery operation:

- Method by which a direct current (DC) is produced
- Current capacity
- Amp-hour capacity
- Voltage applications
- Charge and discharge characteristics
- Battery life expectancy
- Materials used in the battery construction
- Battery physical characteristics, i.e., size, weight
- Environmental requirements for safe battery operation
- Specific component applications

c. Describe the relationship between voltage and current-carrying capacity for series-connected versus parallel-connected batteries.

d. Discuss the basic operation of alternating current and direct current (AC) (DC) generators. Include in the discussion the following elements of generator operation:

- Electromagnetic force
- Counter electromagnetic force
- Generator speed vs. frequency relationship

- Frequency control
- Generator field strength vs. output voltage relationship
- Field excitation
- Generator voltage regulation
- Generator protection circuitry and relaying

e. Discuss the basic operation of the various types of alternating current and direct current motors. Include in the discussion the following elements of motor operation as applicable to alternating current or direct current motors:

- Electromagnetic force
- Counter electromagnetic force
- Starting current vs. running current
- Starting torque
- Current vs. load characteristics
- Variable speed operation
- Speed control
- Motor controller circuitry
- Applications of different types of motors

f. Discuss the purposes of a transformer.

g. Discuss the basic operation of the various types of transformers. Include in the discussion the following elements of transformer operation and design:

- Theory of operation
- Magnetic coupling
- Voltage/current relationships between primary and secondary windings
- Purposes of a transformer
- Step up vs. step down transformer design
- Multiple secondary windings
- Transformer tap changers
- Transformer ratings
- Transformer cooling requirements
- Current transformers vs. potential transformers

h. Discuss the application of specific transformer designs to the following types of electrical/electronic circuitry:

- Instrumentation power
- Voltage sensing circuits
- Current sensing circuits
- Control circuitry power
- Circuits requiring fault isolation protection

i. Discuss application of the following as backup power supplies:

- UPS invertors
- Diesel generators
- Motor generators
- Auto transfer switches

j. Identify and discuss the operation of the different types of electrical switchgear.

k. Identify and discuss the operation of the different types of circuit breakers.

l. Discuss the current, voltage, and insulation ratings of a given type of electrical cable. Include in the discussion this applications for the specific type of cable.

3. Instrumentation and control personnel shall demonstrate a working level knowledge of the characteristics and applications of electrical components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Discuss the various methods through which a supply voltage is converted and/or reduced for use in an electronic circuit.

b. Given a schematic diagram of a typical instrumentation and control circuit, identify each of the following electrical components in the circuit and discuss its function, parameters, and rating as applicable:

- Resistors
- Capacitors
- Relays
- Contacts
- Fuses
- Switches
- Diodes
- Power supplies
- Solenoids
- Indicating lights

c. Discuss the application of the various types of circuit breakers and fuses used in the power supplies to instrumentation and control circuits. Include in this discussion the circuit requirements for the sizing, ratings, and characteristics of these power-interrupting devices.

d. Describe how different types of relays are used in instrumentation and control circuits to accomplish the following functions. Include in the discussion the relay characteristics required for each application.

- Logic control
- Signal isolation

- Electrical protection
- Electrical switching
- Time delays
- Alarm annunciation
- Indication actuation

e. Describe the methods and devices used in instrumentation and control circuits to provide for protection against electrical transients.

f. Identify and discuss the use of electrical test equipment used to troubleshoot and analyze instrumentation and control circuit performance.

g. Describe the requirements for electrical safety class systems.

h. Discuss the factors to be considered when selecting electrical components for use in instrumentation and control circuits. Include in the discussion any consideration that must be given to the environment in which the circuit is required to perform its design function.

i. Discuss the effects of electromagnetic interference on the performance of components in a typical instrumentation and control circuit.

4. Instrumentation and control personnel shall demonstrate a working level knowledge of temperature detection circuitry and components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Discuss the basic functions of temperature detectors.

b. Describe the construction of a basic Resistance Temperature Detector (RTD).

c. Explain how Resistance Temperature Detector resistance varies with changes in sensed temperature.

d. Explain how an Resistance Temperature Detector provides an output representative of the measured temperature.

e. Describe the construction of a basic thermocouple including the materials used.

f. Explain how a thermocouple provides an output representative of the measured temperature.

g. Describe the environmental concerns that can affect the accuracy and reliability of temperature detection instrumentation.

h. Given a diagram of a basic temperature instrumentation detection and control system, describe the function of the following components:

- Resistance Temperature Detector (RTD)
- Bridge circuit
- Direct current-Alternating current converter
- Amplifier
- Balancing motor/mechanical linkage

i. Describe the temperature instrument indications for the following faults:

- Short circuit
- Open circuit

j. Explain the methods of bridge circuit compensation for changes in ambient temperature.

5. Instrumentation and control personnel shall demonstrate a working level knowledge of pressure detection circuitry and components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Discuss the basic functions of pressure detectors.

b. Explain how a bellows pressure detector produces an output signal representative of the measured pressure.

c. Explain how a bourdon tube pressure detector produces an output signal representative of the measured pressure.

d. Explain how a strain gauge pressure transducer produces an output signal representative of the measured pressure.

e. Describe the environmental concerns that can affect the accuracy and reliability of pressure detection instrumentation.

f. Given a diagram of a basic pressure detection device, describe the function of the following components:

- Sensing element
- Transducer
- Pressure detection circuitry
- Pressure indication

g. Discuss the failure modes of the various types of pressure indication instruments.

6. Instrumentation and control personnel shall demonstrate a working level knowledge of level detection circuitry and components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Identify the principle of operation of the following types of level instrumentation:

- Gauge glass
- Ball float
- Chain float
- Magnetic bond
- Conductivity probe
- Differential pressure
- Sonic probes
- Capacitance probes
- Bubblers

b. Explain the process of density compensation in level detection systems.

c. Given a basic diagram of a differential pressure detector level instrument, discuss the functions of the following:

- Differential pressure (D/P) transmitter
- Amplifier
- Indication

d. Describe the operation and applications of the following types of differential pressure detector level instruments:

- Open tank differential pressure transmitter
- Closed tank, dry reference leg
- Closed tank, wet reference leg

e. Describe the environmental concerns that can affect the accuracy and reliability of level detection instrumentation.

f. Discuss the failure modes of the various types of level indication instruments.

7. Instrumentation and control personnel shall demonstrate a working level knowledge of flow detection circuitry and components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Describe the basic construction and theory of operation of the following types of head flow detectors:

- Orifice plates
- Venturi tube
- Dall flow tube
- Pitot tube
- Rotameter
- Nutating disk
- Electromagnetic flow meter
- Ultrasonic flow detector

b. Describe density compensation of a steam flow instrument. Include a discussion of the reason for density compensation and the parameters used.

c. Given a basic diagram of a typical flow detection device, discuss the functions of the following:

- Differential pressure (D/P) transmitter
- Extractor
- Indication

d. Describe the environmental concerns that can affect the accuracy and reliability of flow sensing instrumentation.

e. Discuss the failure modes of the various types of flow indication instruments.

8. Instrumentation and control personnel shall demonstrate a working level knowledge of position indication circuitry and components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Describe the basic construction and theory of operation of synchro position indicators.

b. Describe the basic construction and theory of operation of the following variable output position indicators:

- Potentiometers
- Linear variable differential transformers (LVDT)

c. Describe the basic construction and theory of operation of the following switch position indicators:

- Limit switches
- Reed switches

d. Given a basic diagram of a position indicator, discuss the functions of the following:

- Detection device
- Indicator and control circuit

e. Describe the environmental concerns that can affect the accuracy and reliability of position indication instrumentation.

f. Discuss the failure modes of the various types of position indication instruments.

g. Discuss the functions and operation of position indication switches in motor operated valves.

h. Describe the methods used to test and adjust the position indication switches in motor operated valves.

9. Instrumentation and control personnel shall demonstrate a working level knowledge of radiation detection equipment.

Supporting Knowledge and/or Skills

a. Describe the operation of a proportional counter. Include the following elements in this discussion:

- Radiation detection
- Quenching
- Voltage variations

b. Describe the operation of an ionization chamber. Include the following elements in this discussion:

- Radiation detection
- Quenching
- Gamma sensitivity reduction

c. Given a basic diagram of a proportional counter circuit, discuss the functions of the following:

- Proportional counter
- Preamplifier/amplifier
- Single channel analyzer/discriminator

- Scaler
- Timer

d. Describe how a compensated ion chamber compensates for gamma radiation.

e. Describe the operation of an electroscope ionization chamber.

f. Describe the operation of a Geiger-Müller (G-M) detector. Include the following elements in this discussion:

- Radiation detection
- Quenching
- Positive ion sheath

g. Describe the operation of a scintillation counter. Include the following elements in this discussion:

- Radiation detection
- Three classes of phosphors
- Photomultiplier tube operation

h. Describe the operation of a gamma spectrometer. Include the following elements in this discussion:

- Type of detector used
- Multichannel analyzer operation

i. Describe how the following detect neutrons:

- Self-powered neutron detector
- Wide range fission chamber
- Flux wire

10. Instrumentation and control personnel shall demonstrate a working level knowledge of nuclear instrumentation.

Supporting Knowledge and/or Skills

a. Define the following terms:

- Signal-to-noise ratio
- Discriminator
- Analog
- Logarithm
- Period
- Decades per minute (DPM)
- Scalar

b. Describe the operation of the detectors used in each of the following nuclear instrument applications:

- Source range
- Intermediate range
- Power range

c. Given a basic diagram of a typical source range instrument, discuss the functions of the following components:

- Linear amplifier
- Discriminator
- Pulse integrator
- Log count rate amplifier
- Differentiator

d. Given a basic diagram of a typical intermediate range instrument, discuss the functions of the following components:

- Log amplifier
- Differentiator
- Reactor protection interface

e. Discuss the reason gamma compensation is not required in the power range.

f. Given a basic diagram of a typical power range instrument, discuss the functions of the following components:

- Linear amplifier
- Reactor protection interface

g. Discuss the failure modes of fission chambers, ion chambers, and proportional counters.

11. Instrumentation and control personnel shall demonstrate a working level knowledge of process control systems.

Supporting Knowledge and/or Skills

a. Define and discuss the following process control terms:

- Control system
- Control system input
- Control system output
- Open loop system

- Closed loop system
- Feedback
- Controlled variable
- Manipulated variable

b. Given a diagram of a process control system, describe its operation including the function of the following basic components:

- Controller
- Controlled device
- Feedback elements and signal
- Setpoint/reference signal
- Actuating signal
- Manipulated variable

c. Discuss the factors in a process control system that contribute to process control time lags.

d. Discuss stability in a process control system. Include in the discussion an explanation of converging and diverging oscillations.

e. Discuss the following process control system characteristics and terms:

- Reset control
- Rate control
- Proportional band
- Offset
- Span
- Deviation
- Cascading

f. Describe the operation of the following types of automatic control systems:

- Two-position control system
- Proportional control system
- Integral control system
- Proportional plus reset control system
- Proportional plus reset plus rate control system

g. Discuss the function and operation of the following components of a typical control station:

- Setpoint indicator
- Setpoint adjustment
- Deviation indicator
- Output meter

- Manual-automatic transfer switch
- Manual output adjust knob

h. Describe the operation of a self-balancing control station.

i. Describe the operation of the following types of actuators:

- Pneumatic
- Hydraulic
- Solenoid
- Electric motor

12. Instrumentation and control personnel shall demonstrate a working level knowledge of the characteristics and applications of pneumatic/hydraulic components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a Describe the operation of a basic pneumatic transmitter.

b. Given a diagram of a typical pneumatic control circuit, describe the operation of the control system and explain the function of its components.

c. Explain the term "live zero" as it applies to pneumatic control circuits.

d. Discuss the function and application of the following types of signal converters:

- I/P converter
- P/I converter

e. Describe the operation of a pneumatic actuator used in the following applications:

- Air operated open/close valve
- Air operated throttle valve
- Air operated damper

f. Describe the operation of an electrohydraulic control system.

13. Instrumentation and control personnel shall demonstrate a working level knowledge of the characteristics and applications of electronic components used in instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Describe the operation and application of the following components found in instrumentation and control circuits:

- Summer
- Root extractor
- Gate
- Integrator
- Multiplier
- Proportional device

b. Discuss the uses and applications for microprocessors in an instrumentation and control system.

c. Discuss each of the following terms including their application to instrumentation and control systems.

- Computer memory (Random Access Memory (RAM)/Read-Only Memory (ROM)
- Discreet logic
- Discreet semiconductors
- Analog integrated circuits
- Comparitor circuits
- Combinatorial logics
- Signal conditioning

14. Instrumentation and control personnel shall demonstrate a working level knowledge of systems integration to achieve performance, effectiveness, and cost objectives.

Supporting Knowledge and/or Skills

a. Given a design package for an instrumentation and control system, evaluate its application within an integrated system for the following criteria:

- Instruments and controls meet the general human factors criteria and considerations for safe and efficient system operation.
- Instruments and controls perform within the parameters required for safe and efficient system operation.
- Instrument and control response times are adequate for safe and efficient system operation.
- Instruments and controls are physically configured for safe and efficient maintenance.
- Instruments and controls meet the general design criteria for the system in which they are to be used.

b. Given a proposed application of an instrumentation and control system to an integrated system, evaluate the performance of the integrated system to determine that instrument and control performance requirements will be met.

c. Discuss the problems presented to instrumentation and control systems under various system applications.

15. Instrumentation and control personnel shall demonstrate a working level knowledge of basic thermodynamic concepts and theories used in the design and operation of process control systems.

Supporting Knowledge and/or Skills

a. Define the following terms:

- Specific volume
- Density
- Specific gravity
- Mass
- Weight

b. Describe the thermodynamic properties of temperature and pressure.

c. Compare and contrast the Fahrenheit, Celsius, Kelvin, and Rankine temperature scales, and discuss the concept of "absolute zero."

d. Describe the relationship between absolute pressure, gauge pressure, and vacuum.

e. Define the following and describe their relationship:

- Energy
- Potential energy
- Kinetic energy
- Work
- Heat

f. Describe the following types of thermodynamic systems:

- Isolated system
- Open system
- Closed system

g. Discuss the application of the general energy equation to a process control system.

h. Discuss the application of Bernoulli's principle to a process control system.

16. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of basic heat transfer and fluid flow concepts and theories.

Supporting Knowledge and/or Skills

a. Explain the following terms:

- Static head
- Velocity head
- Friction head
- Head loss

b. Describe the relationship between pressure and flow in a process system.

c. Using the ideal gas law, discuss the relationship between pressure, temperature, and volume.

d. Describe the effects of pressure and temperature changes on confined fluids.

e. Describe how the density of a fluid varies with temperature.

f. Describe the relationship between the pressure in a fluid column and the density and depth of the fluid.

g. Define the terms "mass flow rate" and "volumetric flow rate".

h. Describe the phenomenon of water hammer, pressure spike, and steam hammer.

17. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of mechanical engineering, theories, principles, and techniques.

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of the following types of valves used in a process system:

- Gate valve
- Globe valve
- Flow control valve
- Butterfly valve
- Diaphragm valves
- Check valve
- Relief and safety valves

b. Discuss how valve operation controlled by a process control system can cause water hammer or pressure spiking if the system is not designed properly.

c. Describe the basic operation and pressure/flow characteristics of the following types of pumps:

- Centrifugal pump

- Positive displacement pump

d. Describe the basic design and operation of a compressed air system used to supply instrument air, including a discussion of the function of the following components:

- Compressor
- Moisture separator
- Intercooler
- After cooler
- Receiver
- Air dryer

e. Describe the function and operation of vibration monitoring equipment used to monitor large motors, pumps, and compressors.

f. Describe the basic operation of pressure regulating valves and flow control valves in a process system.

g. Describe the basic theory of operation of a heat exchanger used in a process system.

h. Describe the various methods and characteristics of heat transfer that may occur in a process system.

i. Describe the basic design and operation of a typical heating, ventilation, and air conditioning (HVAC) system including a discussion of the control system used to maintain habitability.

j. Given a process and instrumentation diagram and the technical specifications for a process system, describe the purpose of the system and the major flowpaths.

k. Given a process and instrumentation diagram and the technical specifications for a process system, describe the function of each of the major components of the system

18. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of the geoseismic/civil engineering theories, principles, and techniques that apply to instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Discuss the seismic design constraints imposed on instrumentation and control systems important to safety.

b. Describe the function and operation of instrumentation systems used to measure and annunciate seismic events at defense nuclear facilities.

c. Discuss the effects of vibration on instrumentation and control system performance and reliability, including the methods used to mitigate those effects.

d. Discuss the general factors that affect the seismic qualification of a system, component, or structure.

19. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of the chemical engineering theories, principles, and techniques that apply to instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Discuss the design elements that must be considered when applying instrumentation and control systems for use with chemical processes.

b. Discuss the application of instrumentation and control system components used to measure and control level, flow, temperature, and pressure in chemical process systems that contain corrosive chemicals.

20. Instrumentation and control personnel shall demonstrate the ability to read and interpret electrical diagrams including:

- **One-line diagrams**
- **Schematics**
- **Logic diagrams**
- **Printed wiring board diagrams**

Supporting Knowledge and/or Skills

a. Given an electrical diagram, identify electrical component symbology.

b. Given a logic diagram for a control circuit, identify and describe the effects of an action taken.

c. Identify the symbols used on logic diagrams to represent the components.

d. Explain the operation of the three types of time delay devices.

e. Identify the symbols used to denote a logical "1" (or high) and a logical "0" (or low) as used in logic diagrams.

f. Given a logic diagram and appropriate information, determine the output of each component and the logic circuit.

g. Given a one-line diagram, identify power sources and loads.

h. Given a one-line diagram or schematic diagram, analyze the effects of a component failure in a system.

i. Given a construction diagram, identify the power supplies.

j. Discuss the origin and purpose of "as-built" drawings.

k. Describe printed wiring board fabrication and assembly.

21. Instrumentation and control personnel shall demonstrate the ability to read and interpret mechanical diagrams associated with instrumentation and control systems including:

- **Construction drawings**
- **As-built drawings**
- **Piping and Instrumentation Diagrams (P&ID)**
- **Assembly drawings**

Supporting Knowledge and/or Skills

a. Identify the symbols used for:

- Types of valves
- Types of valve operators
- Types of instrumentation
- Types of instrument signal controllers and modifiers
- Types of system components (pumps, etc.)
- Types and sizes of piping

b. Identify the symbols used to denote the location of instruments, indicators, and controllers.

c. Identify how valve conditions are depicted.

d. Determine the system flowpath for a given valve lineup.

22. Instrumentation and control personnel shall demonstrate the ability to read and interpret engineering fabrication, construction, and architectural drawings associated with instrumentation and control systems.

Supporting Knowledge and/or Skills

a. Given the above drawings, read and interpret the following symbology:

- Basic dimensional and tolerance
- Basic fabrication
- Basic construction
- Basic architectural

b. Given a drawing and a completed product, compare the product against the specifications on the drawing.

23. Instrumentation and control personnel shall demonstrate a working level knowledge of the various computer applications used in instrumentation and control systems engineering.

Supporting Knowledge and/or Skills

a. Describe the applications of computer aided design (CAD) and computer aided engineering (CAE) tools used in instrumentation and control system design functions.

b. Describe the use of computers in the monitoring and control of instrumentation and control systems.

c. Discuss the use of computers in control system analysis and calculations.

24. Instrumentation and control personnel shall demonstrate a working level knowledge of analytical equipment used to measure process chemistry.

Supporting Knowledge and/or Skills

a. List the types of instrumentation used to measure the following process chemistry parameters:

- Conductivity
- pH
- Total dissolved solids
- Silica
- Turbidity
- Chlorine
- Moisture/humidity

b. Explain how each of the following process chemistry parameters is measured and converted to a usable signal for alarm, indication, and control:

- Conductivity
- pH
- Total dissolved solids
- Silica
- Turbidity
- Chlorine
- Moisture/humidity

c. Describe the environmental concerns that can affect the accuracy and reliability of analytical equipment used to measure process chemistry.

d. Discuss the failure modes of the various types of analytical equipment used to measure process chemistry.

e. Describe the methods used to test each of the different types of instruments used to measure process chemistry.

25. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of maintenance management practices related to instrumentation and control activities.

Supporting Knowledge and/or Skills

a. Define each of the following maintenance related terms and explain their relationship to each other.

- Corrective
- Planned
- Preventive
- Reliability Centered
- Predictive

b. Describe the elements of an effective work control program and the documentation used to control maintenance.

c. Discuss the importance of maintaining a proper balance of preventive and corrective maintenance.

d. Define the term "life limiting component" and discuss its impact on facility operation.

e. Identify typical maintenance performance indicators, and discuss their importance.

f. Discuss the relationship between maintenance and Conduct of Operations, Qualify Assurance, and Configuration Management.

g. Discuss the requirements for the receipt and inspection of parts, materials, and equipment.

h. Describe the difference between temporary and permanent repairs/work and the requirements and controls in place to prevent inadvertent modifications.

26. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the instrumentation and control systems related sections and/or requirements of Department of Energy (DOE) Order 6430.1A, General Design Criteria, or applicable design criteria (such as the Uniform Building Code) used by site/facility.

Supporting Knowledge and/or Skills

a. Discuss the purpose and application of the criteria contained in the General Design Criteria.

b. Discuss what constitutes a safety class item as defined in the General Design Criteria.

c. Discuss the application of single failure criteria to instrumentation and control systems.

d. Discuss the environmental qualification criteria for instrumentation and control system equipment.

e. Discuss the requirements for testing capability for instrumentation and control systems as it relates to the General Design Criteria.

f. Discuss the criteria for generic human factors engineering considerations in the General Design Criteria, as they apply to instrumentation and control systems.

g. Given a design package for an instrumentation and control system for a mechanical, civil, structural, or electrical application, determine the general design criteria requirements for the instrumentation and controls.

27. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Standard (STD) DOE-STD-1073-93, Guide for Operational Configuration Management Program.

Supporting Knowledge and/or Skills

a. Describe the purpose and objectives of the Operational Configuration Management Program.

b. Discuss what constitutes acceptable contractor performance consistent with the requirements of DOE-STD-1073-93, Guide for Operational Configuration Management Program, for the following elements of the contractor's Configuration Management Plan:

- Program planning
- Equipment scope criteria
- Concepts and terminology
- Interfaces
- Databases
- Procedures

c. Discuss the following elements of the Configuration Management Program:

- Design requirements
- Document control
- Change control
- Assessments
- Design reconstitution adjunct
- Material condition and aging adjunct

d. Discuss the purpose, concepts, and general process for applying the graded approach to operational configuration management.

28. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Order 4700.1, Project Management System, or 430.1, Life Cycle Asset Management.

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, and application of DOE Order 4700.1 or 430.1. Include in this discussion the key terms, essential elements, and personnel responsibilities and authorities.

b. Given the results from an analysis of contractor noncompliance, determine the potential implications and describe how to communicate these results to contractor and Department management.

c. Discuss the project management terminology for which definitions are provided in DOE Order 4700.1 or 430.1.

d. Discuss in detail the roles played by various management levels within the Department as they relate to the project management system.

e. Discuss the purpose of "key decisions" in the Major System Acquisition (MSA) process. Include in this discussion the responsible authorities for key decisions.

f. Describe the process by which projects are designated as Major System Acquisitions (MSA) or Major Projects.

g. Given a design package for an instrumentation and control system, prepare a project plan using the guidance provided in DOE Order 4700.1 or 430.1.

h. Discuss the requirements that must be met to make a change to a project plan.

29. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

Supporting Knowledge and/or Skills

a. Describe the purpose, scope, and application of the requirements for instrumentation and control systems detailed in IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

b. Discuss what constitutes acceptable contractor performance consistent with the requirements of IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

c. Discuss the following safety system criteria contained in IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations, as they apply to instrumentation and control systems:

- Single failure criterion
- Quality
- Equipment qualification
- Independence
- Capability for test and calibration
- Information displays

d. Discuss the functional design requirements contained in IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations, for the following features of instrumentation and control safety systems:

- Automatic control
- Manual control
- Interaction with other systems
- Derivation of system inputs
- Capability for testing and calibration
- Operating bypasses
- Maintenance bypasses
- Setpoints

- Power source requirements

e. Given a design package for an instrument and control system, demonstrate the ability to verify compliance with IEEE Std. 603-1991, Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

30. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following Instrument Society of America (ISA) Standards related to pneumatic control systems:

- **RP7.1-56, Pneumatic Control Circuit Pressure Test**
- **RP7.7-84, Producing Quality Instrument Air**
- **S7.4-81, Air Pressure for Pneumatic Controllers, Transmitters, and Transmission Systems**
- **S75.13-89, Method for Evaluating the Performance of Positioners With Analog Input Signals and Pneumatic Output**

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, general content, and application of the listed Instrument Society of America Standards.

b. Given a project involving instrumentation and control pneumatic systems, identify the proper Instrument Society of America Standards necessary to effectively evaluate that element of the project.

c. Discuss what constitutes acceptable contractor performance consistent with the requirements of the above Instrument Society of America standards for pneumatic control systems.

d. Given the results from an analysis of contractor nonconformity with the listed Instrument Society of America Standards, determine the potential implications and describe how to communicate the results to contractor and Department management.

e. Given the design drawings and specifications for a pneumatic control system, verify compliance with the appropriate Instrument Society of America Standards.

31. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following Instrument Society of America (ISA) Standards related to process control instrumentation:

- **MC96.1-82, Temperature Measurement: Thermocouples**
- **S26-68, Dynamic Response Testing of Process Control Instrumentation**
- **S37.3-75, Strain Gauge Pressure Transducers**
- **S37.6-76, Potentiometric Pressure Transducers**

- **S37.10-75, Piezoelectric Pressure and Sound Pressure Transducers**
- **S50.1-82, Comparability of Analog Signals for Electronic Industrial Process Instrumentation**
- **S51.1-79, Process Instrumentation Terminology**
- **S67.01-79, Transducer and Transmitter Installation for Nuclear Safety Applications**
- **S67.02-80, Nuclear Safety Related Instrument Sensing Line Piping and Tubing Standard**
- **S67.04-88, Setpoints for Nuclear Safety Related Instrumentation**

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, general content, and application of the Instrument Society of America Standards listed above.

b. Given a project involving process control instrumentation, identify the proper Instrument Society of America Standards necessary to effectively evaluate that element of the project.

c. Discuss what constitutes acceptable contractor performance consistent with the requirements of the above standards.

d. Given the results from an analysis of contractor nonconformity with the listed Instrument Society of America Standards, determine the potential implications and describe how to communicate the results to contractor and Department management.

e. Given the design drawings and specifications for a process control system, verify compliance with the appropriate Instrument Society of America Standards.

32. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following Instrument Society of America (ISA) Standards related to instrumentation and control system drawings and symbology:

- **S5.1-84, Instrumentation Symbols and Identification**
- **S5.2-76, Binary Logic Diagrams for Process Operations**
- **S5.3-83, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems**
- **S5.4-91, Standard Instrument Loop Diagrams**
- **S5.5-85, Graphic Symbols for Process Displays**

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, general content, and application of the Instrument Society of America Standards listed above.

b. Review the design package drawings and specifications for an instrumentation and control system and evaluate conformity with the listed Instrument Society of America Standards, as applicable.

c. Given the results from an analysis of contractor nonconformity relative to the listed Instrument Society of America Standards, determine the potential implications and describe how to communicate the results to contractor and Department management.

33. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following Instrument Society of America (ISA) Standards in relation to the environmental conditions for instrumentation and control system components.

- **S71.01-85, Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity**
- **S71.02-91, Environmental Conditions for Process Measurement and Control Systems: Power**
- **S71.04-86, Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants**

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, general content, and application of the Instrument Society of America Standards listed .

b. Given a project involving the application of an instrumentation and control system, evaluate the environmental qualification of system components for the environmental conditions expected during system operation.

c. Discuss what constitutes acceptable contractor performance consistent with the requirements of the above referenced Instrument Society of America Standards.

d. Given the results from an analysis of contractor nonconformity relative to the listed Instrument Society of America Standards, determine the potential implications and describe how to communicate the results to contractor and Department management.

e. Given the design drawings, specifications, and application for an instrumentation and control system, verify conformity with the appropriate Instrument Society of America Standards.

34. Instrumentation and control personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following Instrument Society of America (ISA) Standards related to process control system control valves:

- **S75.01-85, Flow Equations for Sizing Control Valves**
- **S75.02-88, Control Valve Capacity Test Procedure**

- **S75.07-87, Laboratory Measurement of Aerodynamic Noise Generated by Control Valves**
- **S75.11-85, Inherent Flow Characteristics and Rangeability of Control Valves**
- **RP75.18-89, Control Valve Position Stability**
- **RP75.06-81, Control Valve Manifold Designs**
- **RP75.21-89, Recommended Practice Process Data Presentation for Control Valves**

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, general content, and application of the listed Instrument Society of America Standards for control valve applications.

b. Given a project involving the application of a process control system and control valve actuating devices, evaluate the system performance against the listed Instrument Society of America Standards as applicable.

c. Given the results from an analysis of contractor nonconformity relative to the listed Instrument Society of America Standards, determine the potential implications and describe how to communicate the results to contractor and Department management.

d. Given the design drawings, specifications for an application of a process control system, and control valve actuating devices, verify compliance with the appropriate Instrument Society of America Standards.

35. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) Order 5700.6C, Quality Assurance, as it applies to instrument and control systems [DOE O 414.1 will supersede existing order when issued.].

Supporting Knowledge and/or Skills

a. Describe the types of documents related to instrumentation and control that should be controlled by a document control system.

b. Discuss the requirements for revision and distribution of controlled documents.

c. Discuss the determination of calibration frequency for measuring and test equipment.

d. Describe the effect of using inappropriate calibration standards on test equipment.

e. Discuss the key elements of the procurement process for instrument and control systems as described in the DOE Quality Assurance order.

36. Instrumentation and control personnel shall demonstrate the ability to determine the existence of an unreviewed safety question (USQ) in accordance with Department of Energy (DOE) Order 5480.21, Unreviewed Safety Questions [10 CFR 830.112, Unreviewed Safety Questions, will supersede this order when issued.]

Supporting Knowledge and/or Skills

a. Discuss the reasons for performing an unreviewed safety question determination .

b. Define the following terms:

- Accident analyses
- Safety evaluation
- Technical Safety Requirements

c. Describe the situations in which a safety evaluation is required.

d. Define the conditions for an unreviewed safety question.

e. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities for safety evaluations.

f. Describe the actions to be taken by a contractor upon identifying information that indicates a potential inadequacy of a previous safety analyses or a possible reduction in the margin of safety as defined in the Technical Safety Requirements.

g. Discuss the actions to be taken if it is determined that an unreviewed safety question is involved.

h. Discuss the qualification and training requirements for personnel who perform safety evaluations.

37. Instrumentation and control personnel shall demonstrate a working level knowledge of the Technical Safety Requirements as described in Department of Energy (DOE) Order 5480.22, Technical Safety Requirements [10 CFR 830.320, Technical Safety Requirements, will supersede this order when issued.]

Supporting Knowledge and/or Skills

a. Discuss the purpose of the Technical Safety Requirements.

b. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities regarding the Technical Safety Requirements.

c. Define the following terms and discuss the purpose of each:

- Safety Limit

- Limiting Control Settings
- Limiting Conditions for Operation
- Surveillance Requirements

d. Describe the general content of each of the following sections of the Technical Safety Requirements:

- Use and Application
- Safety Limits
- Operating Limits
- Surveillance Requirements
- Administrative Controls
- Basis
- Design Features

e. Discuss the required approvals for the Technical Safety Requirements for new facilities and, subsequent changes to the Technical Safety Requirements.

f. Discuss the possible source documents that may be used in developing the Technical Safety Requirements.

g. Discuss the conditions that constitute a violation of the Technical Safety Requirements and state the reporting requirements should a violation occur.

38. Instrumentation and control personnel shall demonstrate a working level knowledge of Nuclear Safety Analysis Reports as described in Department of Energy (DOE) Order 5480.23, Nuclear Safety Analysis Reports [10 CFR 830.110, Safety Analysis Reports will supersede this order when issued.]

Supporting Knowledge and/or Skills

a. Discuss the four basic purposes and objectives of Nuclear Safety Analysis Reports.

b. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the development and maintenance of a Nuclear Safety Analysis Report.

c. Define the following terms and discuss the purpose of each:

- Design basis
- Engineer safety features
- Safety analysis

d. Describe the requirements for the scope and content of a Nuclear Safety Analysis Report and discuss the general content of each of the required sections of a Nuclear Safety Analysis Report.

e. Discuss the required approvals for the Nuclear Safety Analysis Report for new facilities and, subsequent changes to the Nuclear Safety Analysis Report.

f. Discuss how contractor management uses the Nuclear Safety Analysis Reports.

39. Instrumentation and control personnel shall demonstrate a working level knowledge of the record-keeping requirements for instrumentation and control systems and equipment as specified by the following Department of Energy (DOE) Orders:

- **DOE Order 4700.1, Project Management System or 430.1 Life Cycle Asset Management**.
- **DOE Order 232.1, Occurrence Reporting and Processing of Operations Information**

Supporting Knowledge and/or Skills

a. Discuss the documentation and reporting requirements for each of the following project status reviews:

- Headquarters reviews
- Project reviews
- Field reviews

b. Prepare and submit the required quarterly, supplemental, and annual reports for a project.

c. Discuss the requirements for Project Manager's Progress Reports.

d. Describe the type of information contained in the Occurrence Reporting and Processing System (ORPS). Include how the data is used by instrumentation and control personnel.

40. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of the training and qualification program(s) requirements identified in Department of Energy (DOE) Order 5480.20, Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities or DOE M 411.1-1, Manual of Safety Management Functions, Responsibilities, and Authorities, which requires DOE 1070-94 standard conformity. [10 CFR 830.340, Training and Qualification, will supersede DOE Order 5480.20 when issued.].

Supporting Knowledge and/or Skills

a. Discuss the meaning of "qualification" and its importance to quality.

b. Describe the purpose and scope of DOE Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities.

c. Discuss why certain skills or proficiencies should be demonstrated periodically.

d. Describe the types of changes to a program or process that require modification to a training program.

41. Instrumentation and control personnel shall demonstrate a working level knowledge of the Department of Energy (DOE) project management system, including how contractor resources are applied to meet instrumentation and control system commitments to quality, safety, cost, and schedule.

Supporting Knowledge and/or Skills

a. Explain the purpose of project management and describe the life cycle of a typical project.

b. Describe the primary roles and responsibilities of instrumentation and control personnel as outlined in DOE Order 4700.1, Project Management System, or 430.1, Life Cycle Asset Management.

c. Describe typical documents and data sources used in project management.

d. Identify, explain, and discuss the relationship of the major elements of a project.

e. Explain the purpose and use of a Project Management Plan (PMP).

f. Discuss the role of quality assurance in relation to project management.

g. Explain the use of safety plans in the management of projects.

h. Discuss the relationship between work breakdown structure (WBS) and cost and schedule.

i. Describe the purpose and use of work packages and/or planning packages.

j. Describe the purpose of schedules, and discuss the use of milestones and activities.

k. Describe the critical path method of scheduling.

l. Explain the concept of a project management baseline and describe the four baselines used in project management.

42. Instrumentation and control personnel shall demonstrate the ability to perform project management duties necessary to provide instrumentation and control technical support to a project.

Supporting Knowledge and/or Skills

a. Given appropriate data, prepare a Project Management Plan (PMP).

b. Given appropriate data, develop a work breakdown structure (WBS).

c. Given appropriate data, develop a project's critical path schedule.

43. Instrumentation and control personnel shall demonstrate a working level knowledge of the Department of Energy/facility contract provisions necessary to provide oversight of a contractor's performance.

Supporting Knowledge and/or Skills

a. Describe the role of instrumentation and control personnel in contractor oversight.

b. Compare and contrast the following:

- The Department of Energy's expectations of an Management and Operating (M&O) contractor.
- Management and Operating (M&O) contractor's expectations of the Department of Energy.

c. Discuss the key elements and features of an effective relationship between the Department of Energy and Management and Operating (M&O) contractor.

44. Instrumentation and control personnel shall demonstrate the ability to participate in the preparation of a risk assessment for the project plan of a major system acquisition (MSA), major project (MP), and other project (OP).

Supporting Knowledge and/or Skills

a. Perform an assessment of project risks that identifies critical systems, subsystems, and other factors that require focused work and resolution.

b. Evaluate the assessed level of risk.

c. Describe the basis for the risk assessment.

d. Identify the critical project elements that contribute to the risk.

e. Identify the consequences of the risk.

f. Develop activities and alternatives to minimize the risk.

g. Identify the stage of the project in which the risk exists.

45. Instrumentation and control personnel shall demonstrate a working level knowledge of the assessment techniques, reporting, and follow-up actions used to evaluate contractor performance.

Supporting Knowledge and/or Skills

a. Describe instrumentation and control personnel's role in performance oversight of Government-Owned Contractor-Operated (GOCO) facilities.

b. Describe the assessment requirements and limitations of instrumentation and control personnel in interfacing with contractor employees.

c. Describe how planning, observing, interviewing, and document research is used during an assessment.

d. Explain the essential elements of a performance-based assessment including the areas of investigation, fact-finding, and reporting. Include a discussion of the essential elements and processes associated with the following assessment activities:

- Exit interviews
- Closure process
- Tracking to closure
- Follow-up
- Contractor corrective action implementation

e. Describe the actions to be taken if the contractor challenges the assessment findings.

46. Instrumentation and control personnel shall demonstrate the ability to assess contractor and/or Federal employee instrumentation and control activities and make all necessary reports.

Supporting Knowledge and/or Skills

a. Given different sets of performance data, compare and contrast the data to highlight acceptable and unacceptable work performance.

b. Describe the methods by which noncompliance is determined and communicated to contractor and Department of Energy (DOE) management.

c. Conduct an assessment of a contractor's instrumentation and control activities and develop and submit the resulting assessment report.

d. Perform an independent assessment of contractor operations.

e. Conduct an interview representative of one that would be conducted during an occurrence investigation.

f. Develop an assessment report using the findings from an assessment.

g. Discuss the results of instrumentation and control assessments in a formal meeting between Department management and senior contractor management.

47. Instrumentation and control personnel shall demonstrate a working level knowledge of problem analysis principles and the techniques necessary to identify problems, determine potential causes of problems, and identify corrective action.

Supporting Knowledge and/or Skills

a. Compare and contrast the immediate, short term, and long term actions taken as a result of problem identification or an occurrence.

b. Given event and/or occurrence data, apply problem analysis techniques and identify the problems and how they could have been avoided.

c. Describe various data gathering techniques and the use of trending/history when analyzing problems.

48. Instrumentation and control personnel shall demonstrate the ability to apply problem analysis techniques necessary to identify problems, determine potential causes of problems, and identify corrective action.

Supporting Knowledge and/or Skills

a. Given event and/or occurrence data, apply problem analysis techniques, identify the problems, and determine how they could have been avoided.

b. Participate in a contractor or Department of Energy (DOE) problem analysis and critique the results.

c. Interpret a fault tree analysis.

49. Instrumentation and control personnel shall demonstrate the ability to act as a Department of Energy subject matter expert for instrumentation and control activities. This ability shall be demonstrated through interaction with Federal, state, local, and public stakeholder representatives during the oversight and management of instrumentation and control programs.

Supporting Knowledge and/or Skills

a. Discuss the roles and responsibilities of site and/or community advisory boards on instrumentation and control issues.

b. Discuss the Department 's position on instrumentation and control issues that impact Federal, state, local, and public stakeholder segments.

c. Discuss the Freedom of Information Act (FOIA) and its impact on the Department's instrumentation and control programs. Discuss security precautions to be taken regarding applicable programs and the Freedom of Information Act.

d. Demonstrate skill in interacting with the public and other stakeholders.

e. Given instrumentation and control-related program data, identify those portions of the data required to be communicated to organizations external to Department of Energy (DOE) instrumentation and control personnel, and discuss any potential impacts on departmental programs.

f. Communicate with Headquarters Program Office representatives, Department of Energy legal representatives, contractors, state, and local officials.

g. Determine the applicability of reports from the Defense Nuclear Facilities Safety Board (DNFSB), the Government Accounting Office (GAO), Tiger Teams, or any entity external to instrumentation and control. Develop implementation plans for Department instrumentation and control programs required by these reports.

50. Instrumentation and control personnel shall demonstrate the ability to define and ensure effective implementation of quality assurance requirements for instrumentation and control system activities.

Supporting Knowledge and/or Skills

a. Discuss the quality assurance measures required for each of the following elements of a project:

- Design control
- Procurement control
- Instructions, procedures, and drawings
- Document control
- Control of purchased material, equipment, and services
- Identification, control, and traceability of materials, parts, and components
- Control of special processes
- Inspection
- Test control
- Calibration and control of test and measurement equipment
- Handling, storage, shipping, and preservation
- Inspection, test, and operating status
- Nonconformity of material, parts, or components

- Corrective action
- Quality assurance records
- Audits

b. Describe the quality assurance organization.

51. Instrumentation and control personnel shall demonstrate the ability to perform technical reviews of Department of Energy (DOE) Orders, standards, guidance documents, and procedures related to instrumentation and controls.

Supporting Knowledge and/or Skills

a. Given one of the listed documents, review it for the following elements:

- Technical adequacy
- Technical accuracy
- Proper format
- Sufficient level of detail
- Properly defined responsibilities
- Procedural steps are concise and easily understood
- References are accurate and current

b. Given an instrumentation and controls surveillance, test, maintenance, or operating procedure, verify procedural adequacy in the following areas:

- Acceptance criteria is identified and accurate
- Quality control is addressed
- Notification requirements are identified
- Procedural cautions are identified
- Proper equipment and material is identified
- Safety concerns are addressed
- Compliance with Technical Safety Requirements
- Compliance with the Safety Analysis Report

c. Given an instrumentation and controls surveillance, test, maintenance, or operating procedure, perform a safety evaluation to determine that an unidentified safety question is not involved.

52. Instrumentation and control personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) maintenance management requirements as defined in DOE Order 4330.4, Maintenance Management program [10 CFR 830.340, Maintenance Management, will supersede this order when issued.]

Supporting Knowledge and/or Skills

a. Explain the Department 's role in the oversight of contractor maintenance operations.

b. Identify the key elements of a contractor maintenance plan as required by a DOE Maintenance Management Program.

c. Describe configuration control and its relationship to the maintenance work control process and the maintenance history file.

d. Describe the mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

e. Review a contractor preventive maintenance activity and describe the preventive maintenance factors to be considered as the activity is planned.

f. Discuss the importance of post-maintenance testing and the elements of an effective post-maintenance testing program.

g. Review the results of post-maintenance testing activities and discuss the acceptance of post-maintenance testing.

h. Discuss the importance of maintaining a maintenance history.

i. Review a maintenance history file and discuss the potential implications of repeat maintenance items.

j. Explain the intent of a Maintenance Problem Analysis Program and discuss a maintenance problem where this program has been employed.

APPENDIX A
CONTINUING EDUCATION, TRAINING AND PROFICIENCY PROGRAM

The following list represents suggested continuing education, training and other opportunities that are available for instrument and control personnel after completion of the competency requirements in this technical Functional Area Qualification Standard. It is extremely important that personnel involved with instrument and control maintain their proficiency through continuing education, training, reading, or other activities such as workshops, seminars, and conferences. The list of suggested activities was developed by the Subject Matter Experts involved in the development of the Functional Area Qualification Standard and is not all-inclusive.

Based on the knowledge and experience of the Subject Matter Experts, it is suggested that [*to be determined*] learning activities per [*to be determined*] are necessary to maintain proficiency in the instrument and control functional area after completion of the competencies in the Standard and other requirements of the Technical Qualification Program.

LIST OF CONTINUING EDUCATION, TRAINING AND OTHER ACTIVITIES

1. A periodic review of DOE orders and standards to make sure the most current requirements are known and followed by site/facilities.

2. A periodic review of Institute of Electrical and Electronic Engineers (IEEE) standards to make sure the most current requirements are known and followed by site/facilities.

3. A periodic review of International Society for Measurement and Control (ISA) standards to make sure the most current requirements are known and followed by site/facilities.

4. Self-study or formal training courses to maintain a current level of competency.

5. Attendance at trade conferences and workshops to maintain a current level of competency.

6. ISA maintains a web-site for its Training Institute at *http://www.isa.org/training/index.cfm*. This site provides developmental activities based on different paths such fundamentals, technical, engineering, and industrial computing skills.

7. General Physics (GP) offers a number of courses that are advantageous for the instrument and control specialist:

    a. Course #0542 *Electronics for Electricians*
    b. Course #9402 *Basic Protective Relaying*
    c. Course #8805 *Electrical Industrial Plant Maintenance*
    d. Course #8807 *Motors and Motor Controllers*
    e. Course #9116 *Generators and Voltage Regulators*
    f. Course #8808 *UPS Systems*
    g. Course #8806 *Diesel Generators and Controls*
    h. Course #0543 *Power Distribution and Switchgear Maintenance*